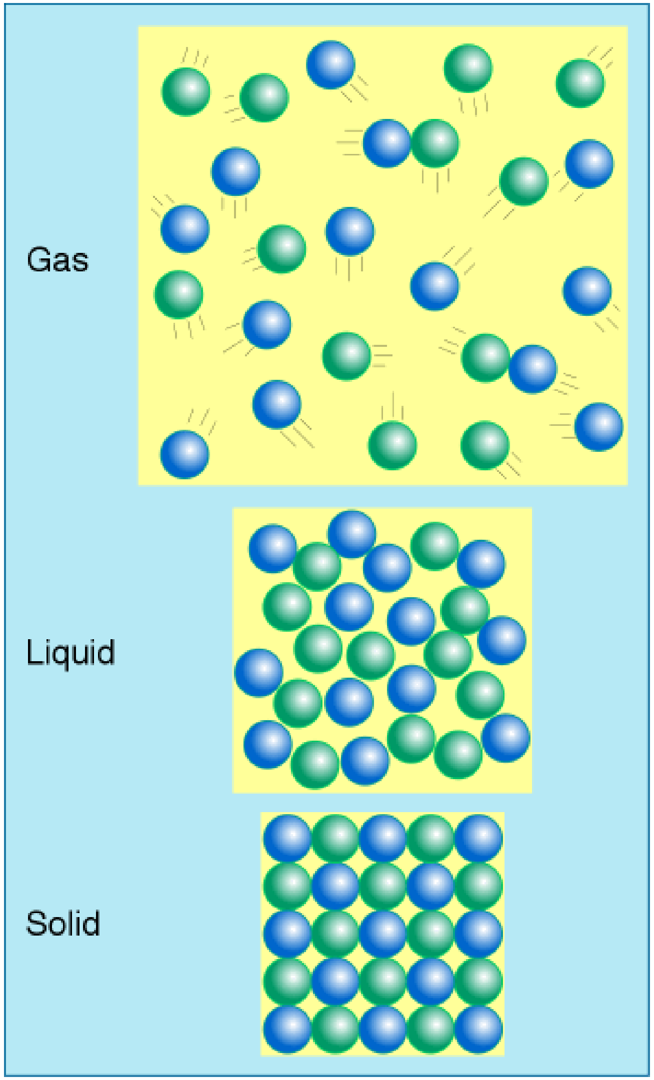
Liquids and Solids

Kinetic Molecular Theory

- Mostly applied to gases
- Four postulates:
  - The volume of the individual particles of a gas can be assumed to be negligible.
  - The gas particles are in constant motion. The pressure exerted by the gas is due to the collisions of the gases with the walls of the container.
  - The average kinetic energy of a gas is directly proportional to the Kelvin temperature
  - <u>The gases are not attracted to one another.</u>
- Changes slightly for liquids and solids

Kinetic Molecular Theory

- Gases—Attractions are insignificant
- Liquids—Attractions are more important leading to a more ordered state
- Solids—Attractions are most important with an ordered state

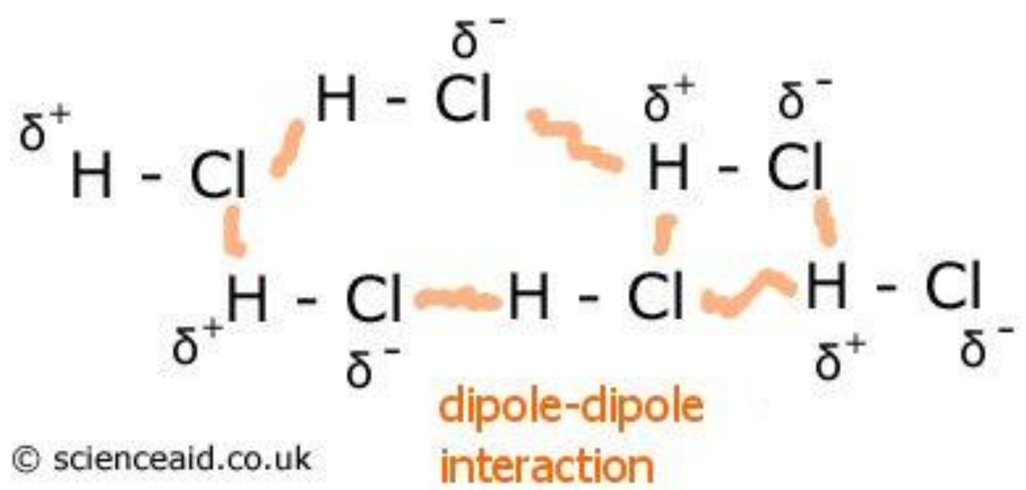


Intramolecular vs. Intermolecular Forces

Intramolecular Forces	Intermolecular Forces
Ionic bond	Hydrogen bonding
Covalent bond	Dipole-dipole
	London dispersion

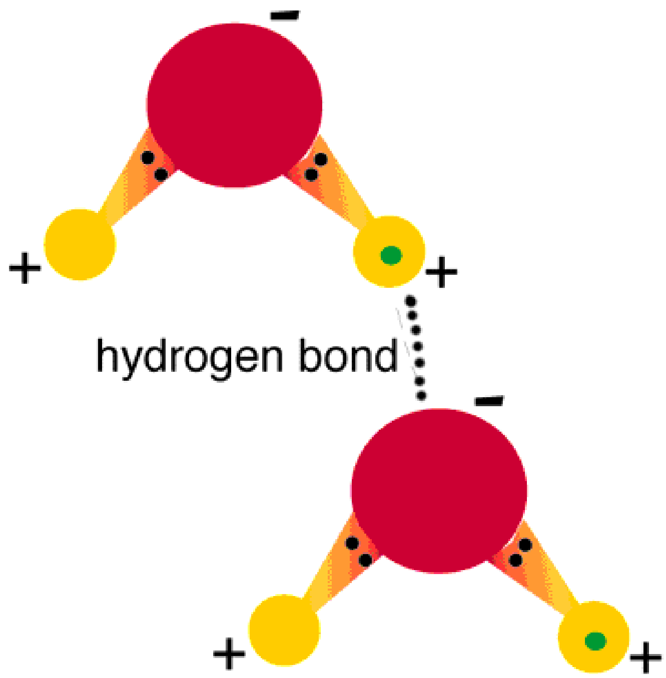
Dipole-dipole Attractions

- Attraction between dipoles
  - Dipole = partial positive and partial negative portion of a molecule due to difference in electronegativity
- Partial positive portions line up with partial negative portions
- Leads to higher boiling points
- Example: SO_2



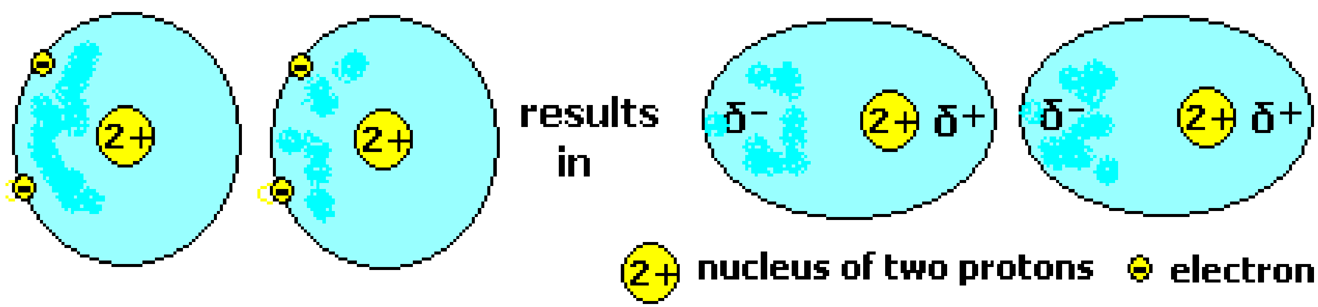
Hydrogen Bonding

- Unusually strong dipole-dipole attraction involving hydrogen
  - Occurs between hydrogen bonded to nitrogen, oxygen, or fluorine
- Example: H_2O, NH_3, and HF



London Dispersion Forces

- Found in all molecules
- Temporary shift in electron cloud, creating ‘momentary dipole’
- Larger atomic number and electron cloud creates a larger ‘momentary dipole’
- Explains common state of matter for different elements
  - F_2 and Cl_2 (gas), Br_2 (liquid), I_2 (solid)

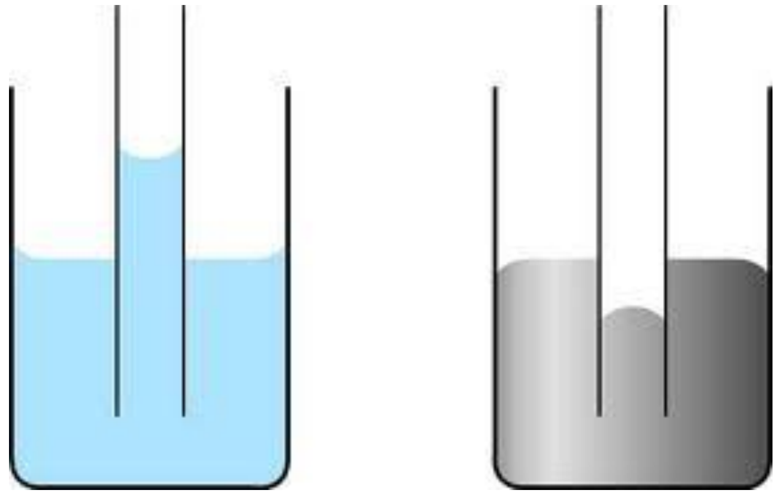


Properties of Liquids

- Surface Tension
  - The resistance of a liquid to increase its surface area
  - Strong intermolecular forces = high surface tension

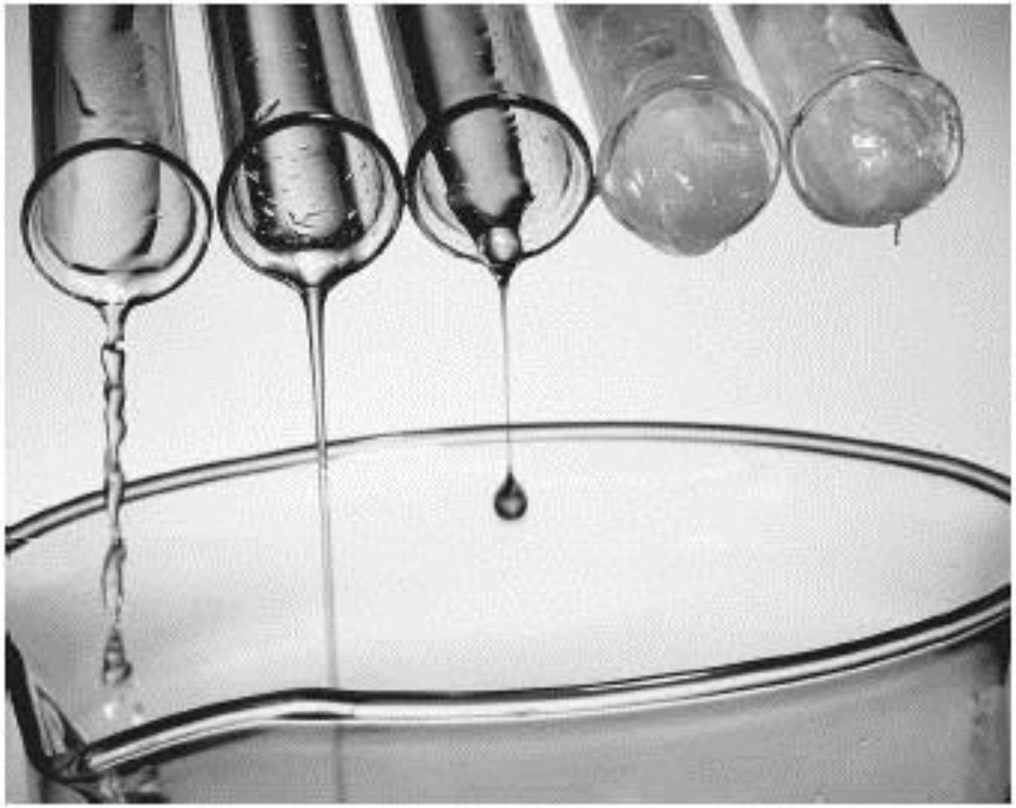
Properties of Liquids

- Capillary Action
  - The rise of liquids up very narrow tubes
  - Contributed by two opposing forces
    - Adhesive forces—attractions between a liquid and its container
    - Cohesive forces—intermolecular forces in the liquid that try to decrease the liquid's surface area



Properties of Liquids

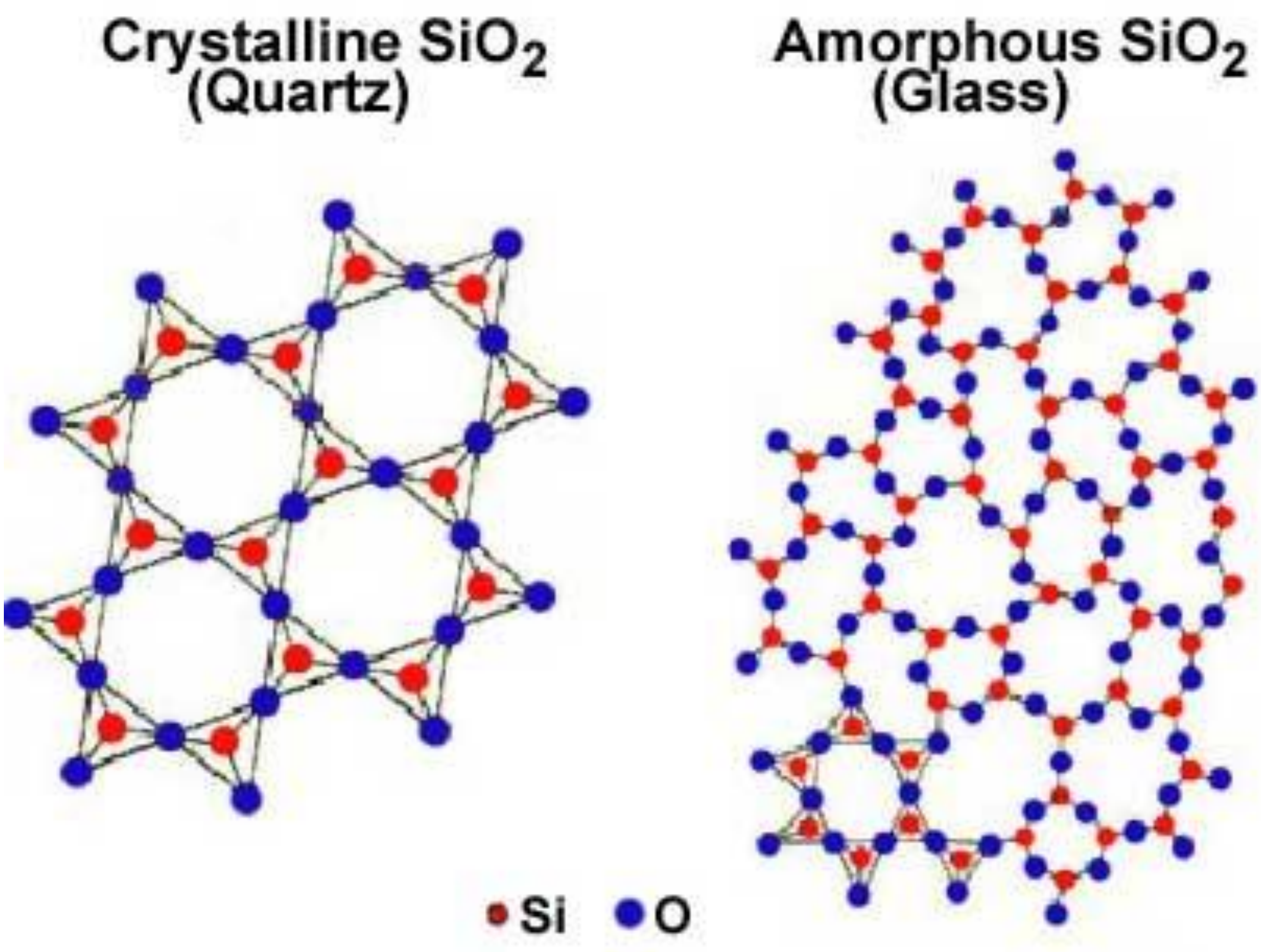
- Viscosity
  - A measure of a liquid's resistance to flow
  - Higher viscosity = larger intermolecular forces
  - Decreases with temperature
    - More energy to overcome intermolecular forces



Solids

- Two types:
  - Amorphous solid—those with considerable disorder in their structures
  - Crystalline solid—those with a highly regular arrangement of their components
- Structure of crystalline solid
  - Lattice—a three-dimensional system of points designating the positions of the components (atoms, ions, or molecules) that make up the substance
  - Unit cell—the smallest repeating unit of a lattice

Crystalline versus Amorphous Solid

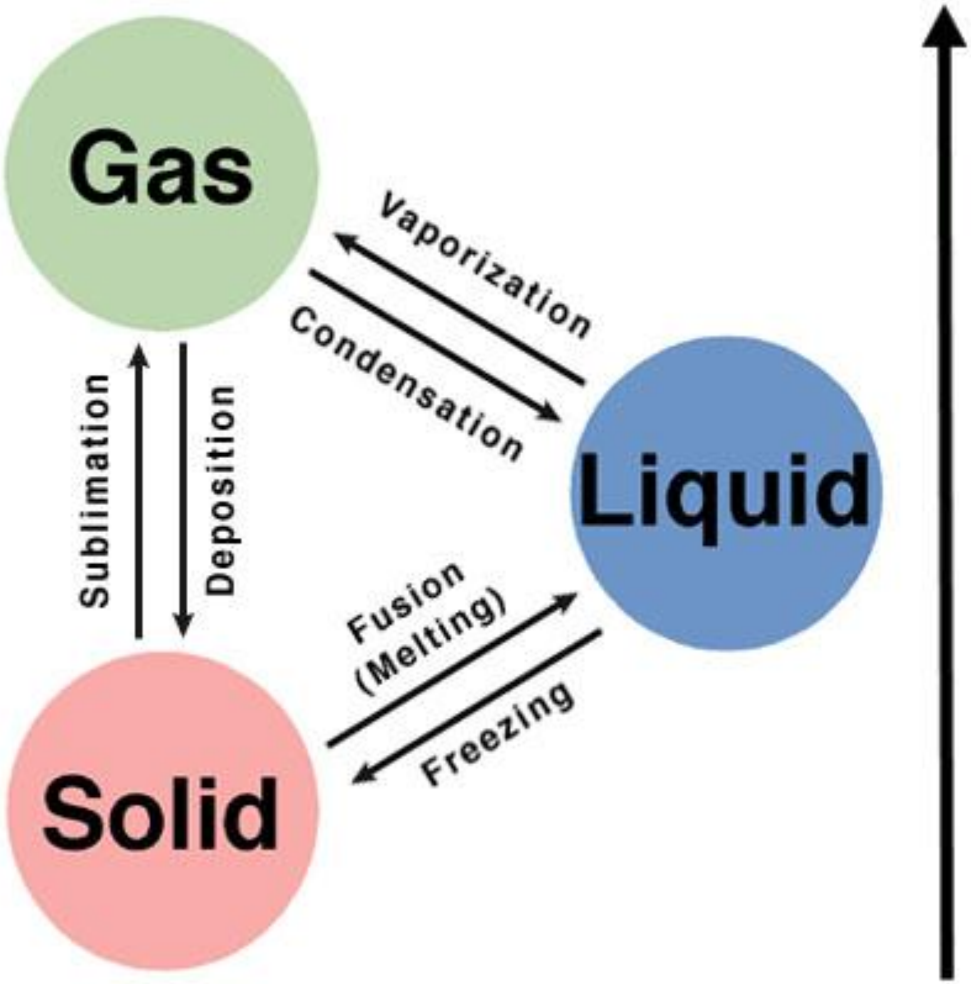


Types of Crystalline Solids

Property	Molecular	Ionic	Atomic	Metallic	Network Covalent
Example	$C_6H_{12}O_6$	NaCl	Ar	Cu	C (diamond)
Particles in lattice points	Molecule	Ions	Atoms	Atoms	Atoms
Bonds/Forces between lattice points	Dispersion forces	Ionic bond	Dispersion forces	Metallic bond	Covalent bond
Melting points	Low	High	Low	High (1083 °C)	Very High (3500 °C)
Electrical Conductivity	None	Yes (melted)	None	Yes (solid & melted)	None
Other Properties		Brittle		Malleable and Ductile	Insulator Very Hard

Phase Changes & Phase Diagram

Phase Changes



Phase Diagram

- Graphically summarize the phase transitions between the states of matter of a substance based on pressure and temperature conditions
- Key features:
  - Triple point—combination of temperature and pressure at which all three states of matter are in simultaneous equilibrium
  - Critical temperature—the temperature above which the vapor cannot be liquefied regardless of the pressure applied
  - Critical pressure—the pressure required to produce liquefaction at the critical temperature
  - Critical point—the point of the critical pressure and the critical temperature

Phase Diagram